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PROTOTYPE DEVELOPMENT, MODELING OF 3-R SERIAL ROBOT

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ABSTRACT

In this scientific work a novel 3-R robot is designed which is three degrees of freedom arm of robotic manipulator, that can pick and place small sized objects in three-dimensional space. This 3-R Robot comprises three revolute joints, a mechanical gripper, two rectangular cross sectioned links, rotary table and rectangular platform. The robot is compatible with three-dimensional movement and can be multifunctional by changing end effect or means. After building the software model using robo analyzer the maximum joint movements are evaluated, through which fixing work location, distance moved by End effect or can be decided based on maximum joint displacements. Thus, this paper facilitates a process of avoiding singular positions of future applications based on 3R Robots

KEYWORDS: Motor, 3-R Robot & Robot Arm

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Original Article

1. INTRODUCTION

In the present advanced industrial ere, the replacement of human by robot is increasingly sought after due to repeatability, accuracy and safety in dangerous environments. However, at the same time, we are a leap short of achieving the versatility of the robot so that cost of robotic deployment will be marginally reduced.

Robotic manipulators are made up of a rigid kinematic chain of various links which are connected, directly driven, linear(prismatic/translational) or revolute(rotary)joints. By employing rigid joints, joint actuators and rigid links high payloads with high speed movement and superior positional will be achieved. Apart from rigid elements, slackness in the gears and the deformations in the links, that occurs under pay load, should be avoided. The heavy, solid construction of robotic manipulator arm may result in lower load weight to dead weight ratio which is inferior when compared with humans and animals. So, the cross-sectional changes are introduced to by removing some material and retaining I or Box Sections of the links.

2. LITERATURE REVIEW

The end-effector's (EE) motion produced by robot controller is detailed in [1], by using software like roboanalyzer finding the D-H parameters. In this industrial application and the functionality, meticulous design of bionic robot arm. The 3biconicallyactuated main axes are also supported by a regular 3 DOF wrist in [2]. Article [3] describes use of parallel mechanism robot manipulator is upcoming technology in the arena of robotics, forward kinematic and inverse kinematic analysis. Pick and place lightweight objects based on a color sorting mechanism is primarily made of three joints, hand, the purpose of this study in [4]was to model three degrees of freedom robotic manipulator arm which is capable of picking and placing small size objects from one location to another in 3D space. Automatic walkways for pedestrians and robotic actuation controls are elaborately discussed in [5-11].

Medical applications of Parallel robots were outlined in [12-14]. Home automation system for divyang persons is designed and presented in [15-19]. Singularity analysis is carried out by [20] for 6-DoFKukarobot. The objectives of current work are to do prototype and development of project and pick and place of a rectangle plate. The design of 3 DoF serial robotic arm, its mechanical structure has been developed by roboanalyzer software.

- Layout of robotic arm
- Kinematic analysis of robotic arm [D-Parameters].

It is mostly used in automobile industry, small scale sectors. Mainly for assembly of any kind of works, pick and place mobility.

3. FABRICATION

Material selection: Wood, Dc motors, Gears, Switches, Wires, Batteries

Assembly procedure:

- Cut the wood into required dimensions
- First fix the motor to the base to move left to right.
- Next the arm to the base and the motor has to fix to move up and down.
- End effect or has to fix to the arm and the end effect or has to fix the motor to move close and open type.
- Give the wiring to the motor and to the switch’s connections.

General maintenance:

- The wiring has to maintain correctly
- Proper batteries have to maintain

Figure 1: Robot with Electric Connections

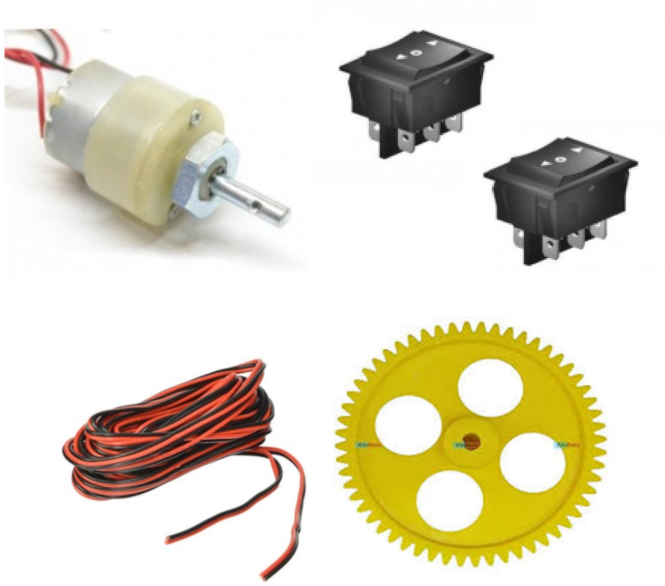

Figure 2: Motor, Switches, Cable and Spur Gears

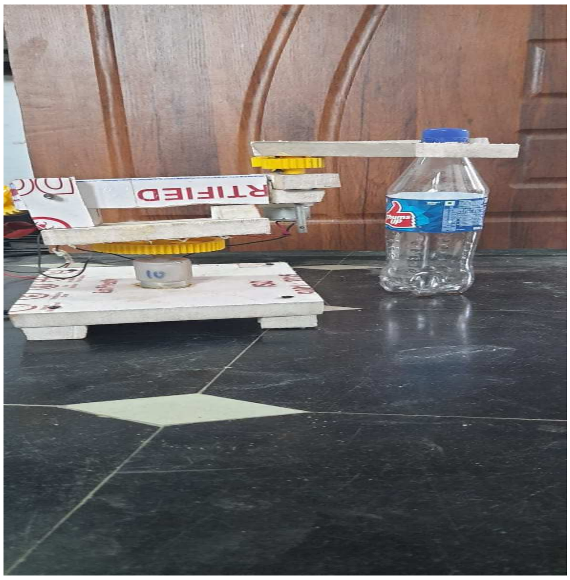

Figure 3: Pick and Place by Robot Prototype

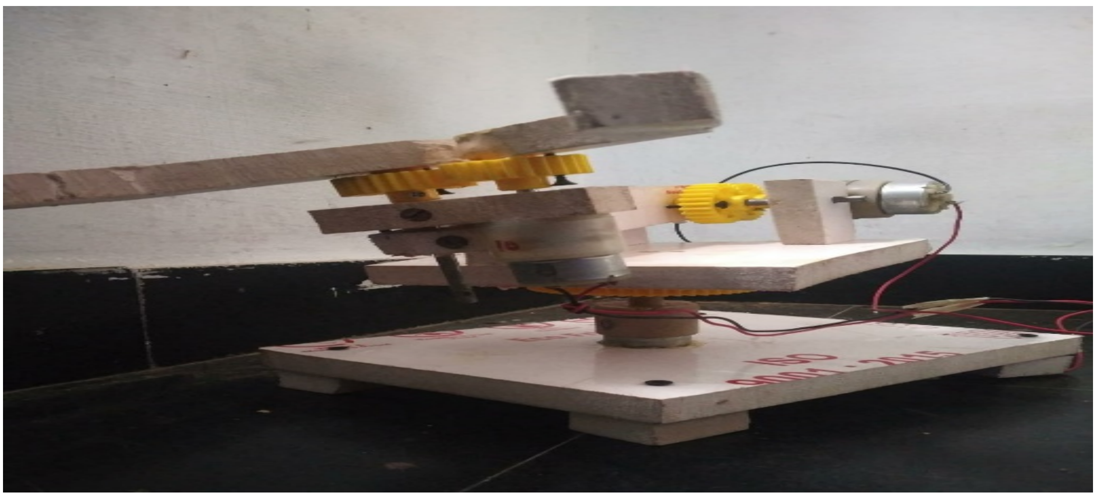

Figure 4: Rear View of Robot Prototype with Gear Trains

COST REPORT

S.No	Material	Cost(Rs)
1	Wood	500
2	Gears,wires,batteries Nuts	300
3	DC motors	360
4	Tools	340
5	Clamp, handsaw	120
6	Miscellaneous	280
	Total	**1900/-**

4. METHODOLOGY

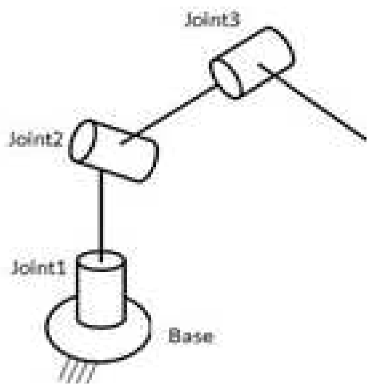

Figure 5: A 3-Degree of Freedom Serial Robot.

FORWARD KINEMATICS(FK): In FK, A set of joint angles is used to find End effect or (EE)pose. One and only one output solution exists. Mathematically

$$EE(pose) = f(\theta_1, \theta_2, \theta_3)$$
$$\text{here } pose = X, Y, Z, \phi, \theta, \varphi$$

Where θ_1, θ_2, θ_3 are joint angles of Joint1, Joint2 and Joint3 respectively

X, Y and Z are linear co-ordinates of EE position where as Φ, θ, φ are row, pitch and yaw angles of EE.

INVERSE KINEMATICS(IK): In IK, A given pose of End effector yields multiple sets of Joint angles. So multiple solutions exist.

$$(\theta_1, \theta_2, \theta_3) = f(EE(pose))$$
$$\text{here } pose = X, Y, Z, \phi, \theta, \varphi$$

5. MODELING AND SIMULATION

From the Robot prototype, dimensions are measured and translated into D-H parameters by visual inspection. Using the D-H Parameters (presented in table.1), Robot model is created in Roboanalyzer. Below are the D-H Parameters of the prototype.

Table 1: D-H Parameters of the Prototype

Joint Number	Type of Joint	Joint Offset (b) in Meters	Joint Angle (theta) in Degrees	Link Length (a) Meters	Twist Angle (alpha)	Initial Value (JV) degrees	Final Value (JV) Degrees
1	Revolute	0.08	Variable	0	90	0	0
2	Revolute	-0.06	Variable	0.14	-90	0	0
3	Revolute	0	Variable	0.13	0	0	0

Figure 6: Software Model of 3-R Robot.

From the observation of model and prototype, it is understood that Joint1 can be moved between (0,360) degrees, whereas Joint2 can be displaced between (0, 60) degrees and joint3 may be moved between (0, 20) degrees on either side without being self-constrained. For a Motion planning with following joint jogging, the Joint angle, Joint Velocity and Joint acceleration versus time graphs are shown in figure 7, figure 8 and figure 9.

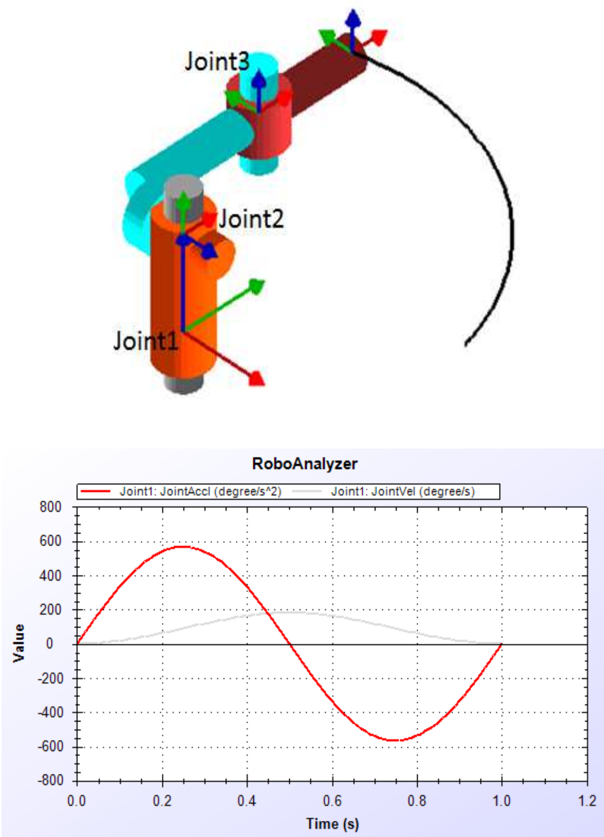

Figure 7: Joint 1 Rotation (0° to 90°), Joint Velocity & Joint Acceleration Graphs for Joint 1.

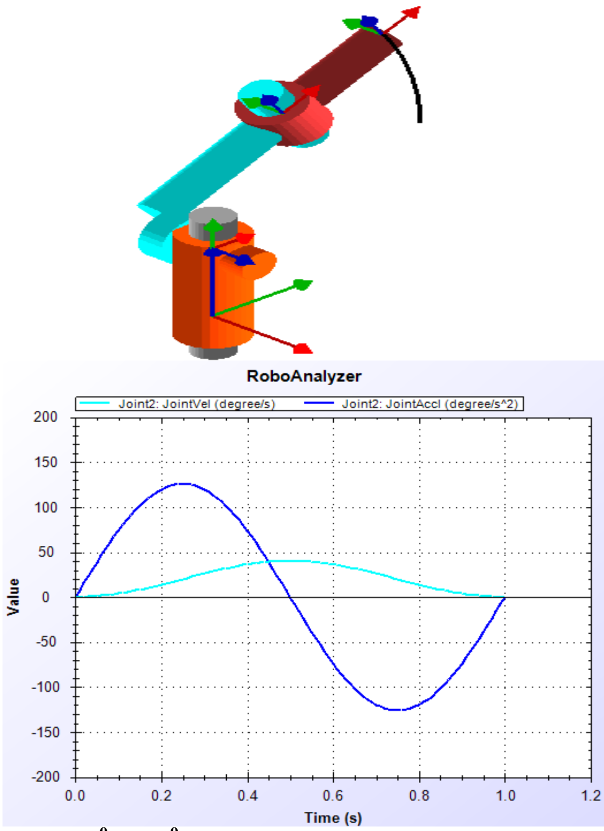

Figure 8:Joint 2 Rotation (0^0 to 20^0), Joint Velocity & Joint Acceleration Graphs for Joint 2

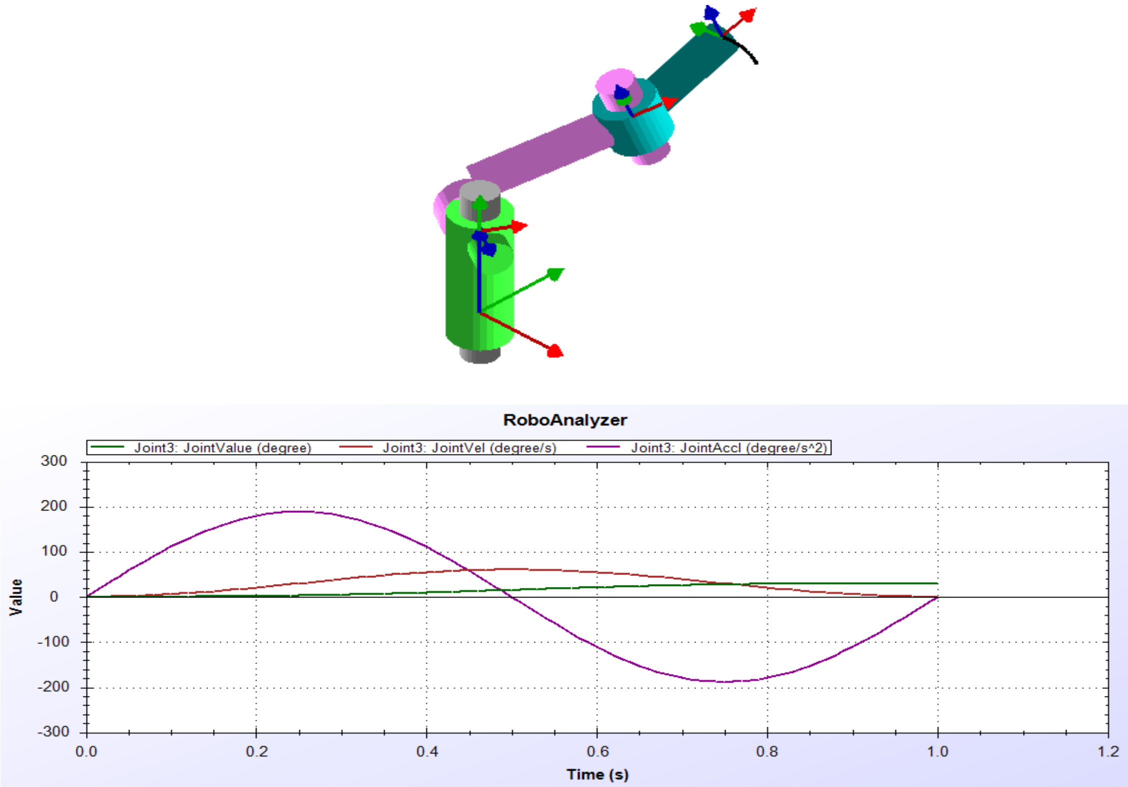

Figure 9: Joint 3 Rotation (0^0 to 30^0) for Gripper Open, Joint velocity & Joint Acceleration Graphs for Joint 3

Graphs

Link 1

X, Y, Z Directions

Linear position of link's end tip with respect to the Global Co-ordinate system with origin at the base of the Robot.

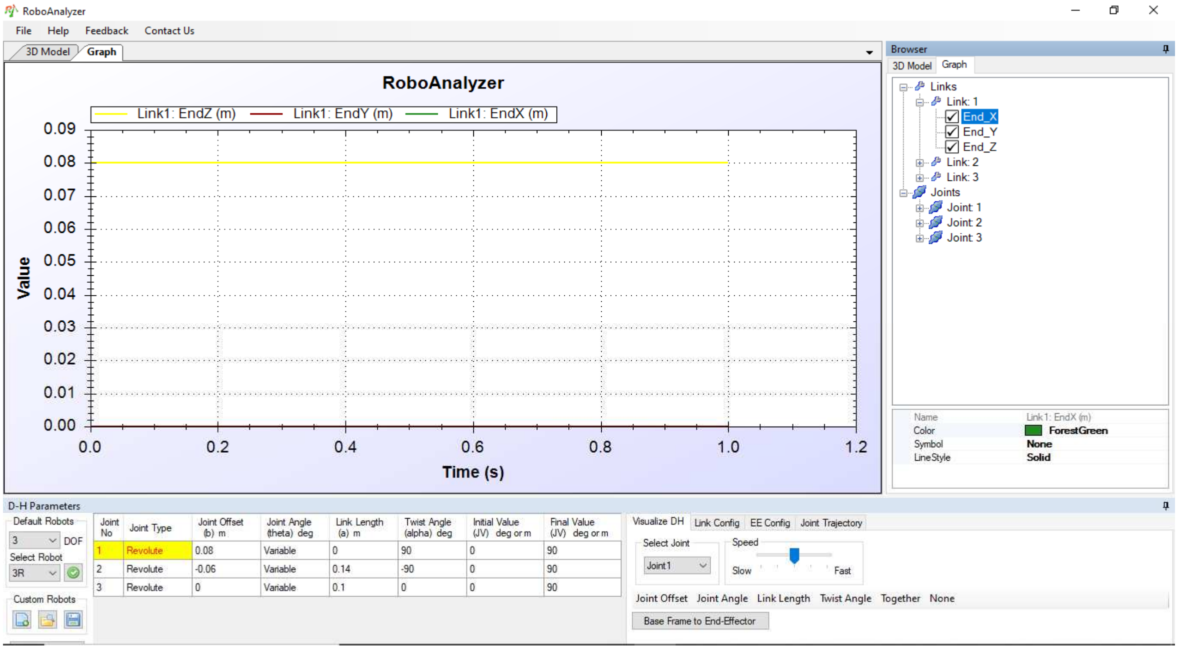

Figure 10: Link1 End point values Vs time

Link 2

In X, Y, Z , Directions.

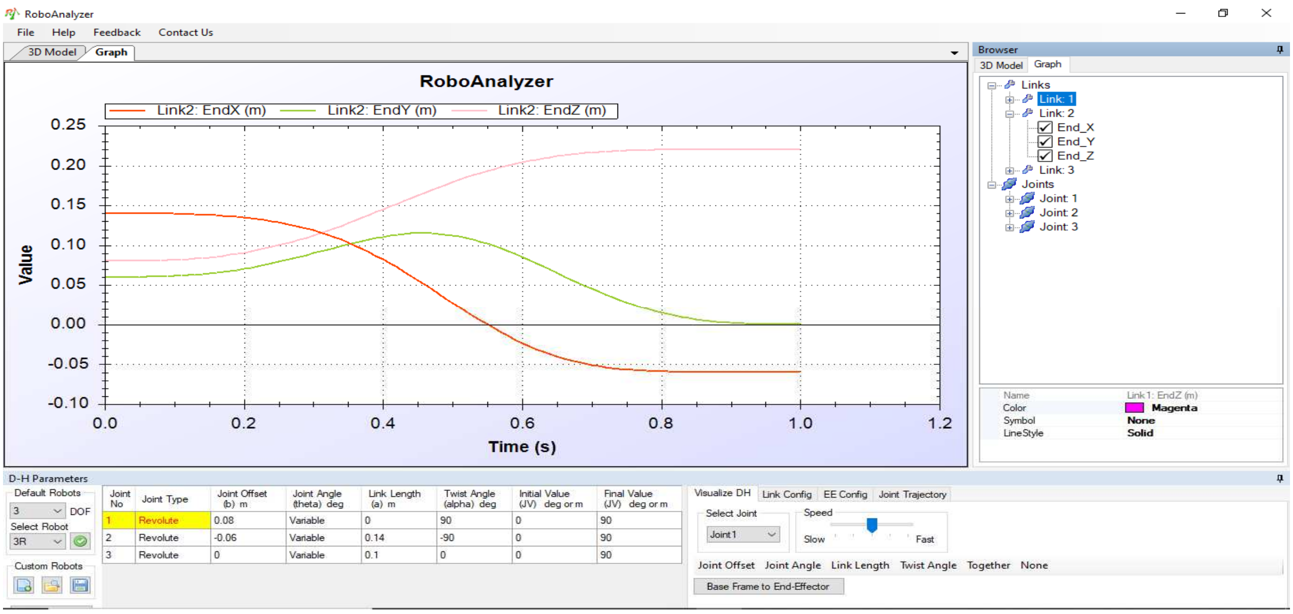

Figure 11: Link2 End point values Vs time

Link 3:

In X, Y, Z , Directions

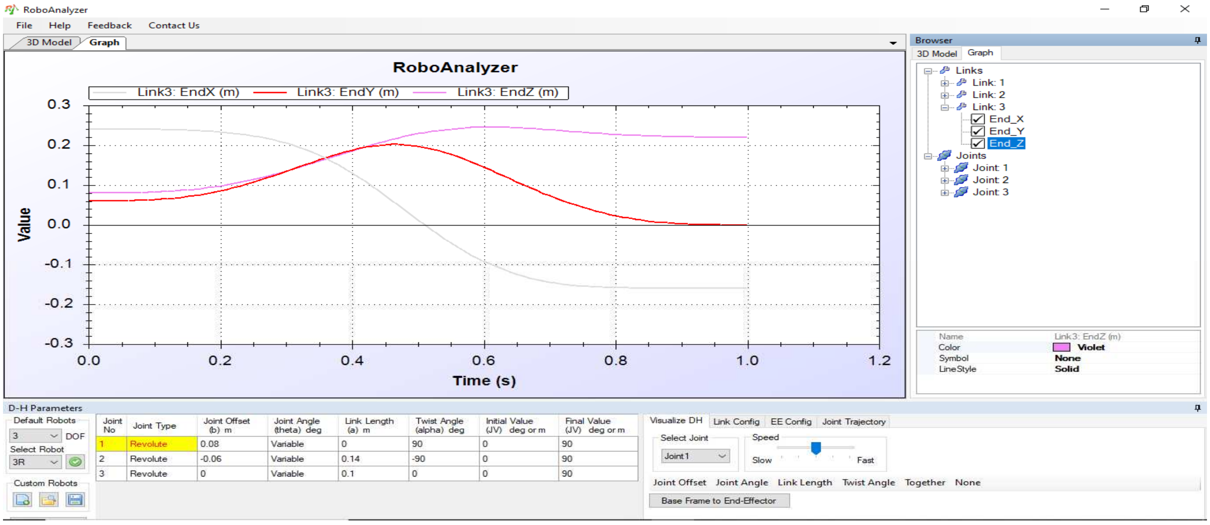

Figure 12: Link 3 End Point Values Vs Time

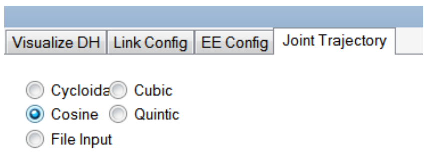

Figure 13: Choosing Joint Trajectory Program for Path Execution

One out of Cycloidal, Cubic, Cosine or Quintic Trajectory planning modules may be selected. For the given Joint angles motion, the Joint Velocity and accelerations w.r.t to time vary according to the Joint trajectory program chosen. Contrary by choosing file input, the values of Joint velocities, Joint accelerations are explicitly provided along with Joint angle values at each of the time step during motion along the required path profile.(Ref. figure 13)

CONCLUSIONS

In the current work a robot prototype is fabricated and using its D-H parameters extracted, a software model is created. This model is analyzed for maximum joint displacement in positive and negative directions. So, this work facilitates a process of avoiding singular positions of future applications based on 3R Robots. This data may be compared with industrial requirements and re-modeled, tested and confirmed before producing full size robot.

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